BRIEFING ON PERFORMANCE AND PROFICIENCY TESTING OF ORGANIZATIONAL TRACK VEHICLE MECHANICS AND MAINTENANCE SERGEANTS

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Human Resources Research Organization

Prepared for:

Office, Chief of Research and Development (Army)

13 October 1961

MOBILITY IV & V
DIV. 2
OCT 61

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U.S. Army Armor Human Research Unit
Fort Knox, Kentucky

Under the Technical Supervision of

The George Washington University
HUMAN RESOURCES RESEARCH OFFICE
operating under contract with
THE DEPARTMENT OF THE ARMY

REPORT DOCUMENTATION PAGE | READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
BRIEFING ON PERFORMANCE AND PROFICIENCY TESTING OF ORGANIZATIONAL TRACK VEHICLE MECHANICS AND MAINTENANCE SERGEANTS

5. TYPE OF REPORT & PERIOD COVERED
Briefing

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(S)
John P. Smith

8. CONTRACT OR GRANT NUMBER(S)
DA 44-188-ARO-2

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Human Resources Research Organization (HumRRO)
300 North Washington Street
Alexandria, Virginia 22314

10. PROGRAM ELEMENT PROJECT TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
Office of the Chief of Research and Development
Department of the Army
Washington, D.C. 20301

12. REPORT DATE
October 1961

13. NUMBER OF PAGES
10

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
Cleared for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES
Briefing for U.S. Continental Army Command. Research performed by HumRRO Division No. 2 (now Central Division, Louisville Office, Kentucky) under MOBILITY IV--The Performance of Organizational Maintenance by Track Vehicle
(Continued)

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
armor maintenance
organizational maintenance
proficiency testing
track vehicle mechanics

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
The performance of organizational track vehicle mechanics (TVMs) in four types of tasks--testing, troubleshooting, adjusting, and inspecting--was tested by an eight-hour test of 30 individual exercises. Army organizational maintenance Sergeants and Senior Track Vehicle Mechanics with less than one year, one-five years, and over five years on the job were also tested to
(Continued)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

18. SUPPLEMENTARY NOTES (Cont.)

Mechanics and MOBILITY V--The Proficiency of Armor Organizational Maintenance Sergeants and Senior Track Vehicle Mechanics.

20. ABSTRACT (Cont.)

determine how proficiency changes with experience. Results of tests indicate that mechanics trained in the TVM course were superior to the on-the-job trained men. Findings also indicate very little gain in proficiency with increased years of experience on the job.

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Briefing on Performance and Proficiency Testing of Organizational Track Vehicle Mechanics and Maintenance Sergeants

by

John P. Smith

13 October 1961

Briefing for the U.S. Continental Army Command

U.S. Army Armor Human Research Unit
HUMAN RESOURCES RESEARCH ORGANIZATION

CONARC BRIEFING ON TASK MOBILITY

As was pointed out in Col. Michaelson's introductory remarks, Task MOBILITY has been in the HumRRO work program as a Conarc requirement. This implies reservations, here at Conarc, about the proficiency of organizational maintenance personnel. You will see that these reservations are well founded.

Since there may be people here who have not served in Armor organizations, at least for a number of years, it may be well to recall to mind who "organizational" maintenance personnel are, and what they do.

"Organizational" means Company and Battalion maintenance sections made up of Track Vehicle Mechanics (TVMs), MOS 632.2 and 632.6, and maintenance sergeants, MOS 632.6 or higher. These sections are organic to tactical organizations, and maintain all tactical vehicles. The Battalion section has some equipment that the Company section does not have, notably a welder, a wrecker, and some special purpose equipment for which they have storage and transportation facilities lacking in the Company. The Battalion also stocks some spare parts. Skill-wise, however, there is no difference between the personnel of the two maintenance sections. There is no provision for sorting out men according to skill, experience, or training, and assigning the superior ones to either section. In practice, the Company TVMs may work in the Battalion section or vice versa, according to local SOP and problems which may arise.

The work of organizational TVMs consists of the following types of tasks, as set forth in Technical Manuals and TM Maintenance Allocation Charts: servicing, repairing, replacing, removing and

installing, testing, trouble shooting, adjusting and inspecting. We tested in the last 4 of these areas and I will explain why.

(SLIDE 1)

Servicing, generally speaking, refers to 1st echelon or crew functions such as lubrication and cleaning. The scheduled Quarterly-service, or Q-check performed mainly by the Battalion maintenance section consists mostly of small repairs plus certain required tests such as the dye test performed by Ordnance on oil cooler fans.

"Repairing," in organizational maintenance, does not mean what it sounds like. It refers either to a very simple action, such as taping hatch padding, or it means replacing something, such as a defective track block or generator. The vehicle is repaired by replacing defective components or assemblies; the assembly itself is sent elsewhere for repair or disposal. Organizational mechanics are not authorized to repair any assembly that must be taken apart; they may only remove and replace.

"Replacing," and "removing and installing" are self-evident. Generally speaking, these four categories of tasks account for most of the man-hours or make up the routine work of the maintenance section. The point I wish to make is not simply that routine tasks are routine, but that they all follow from somebody's decision that they must be done. While servicing is done on a calendar or mileage schedule, the remaining actions occur on demand. They are done when someone decides they must be done, and this means that testing, trouble shooting, adjusting and inspecting are necessary pre-conditions for the efficient and economic conduct of the more routine tasks.

Not only are these four categories of tasks basic to the more

SLIDE 1

THE ORGANIZATIONAL TRACK VEHICLE MECHANIC DOES:

SERVICING

REPAIRING

REPLACING

REMOVING AND INSTALLING

and

TESTING

TROUBLE SHOOTING

ADJUSTING

INSPECTING

routine work, they also are very important in their own right. Testing enters into evaluation of the vehicle's state of readiness, into decisions to turn it in to Ordnance or keep it in service, and is also frequently a part of trouble shooting.

Trouble shooting is done when the engine or one of its sub-systems is disabled by a malfunction whose nature is not apparent, or when the vehicle's usefulness is impaired, as by a failure of the light system. Adjusting is necessary for efficiency of the power plant, as in carburetor adjustment or ignition timing; for safety as in brake and steering linkage; and may also have a preventive function as in correct gear band adjustment. Inspection contributes to determination of work required, evaluation of work done, to safety, prevention of damage, and estimation of readiness.

You recognize the importance of these four types of task.

There are two more reasons why we chose to test proficiency in these last four areas of work. First, they are complex tasks of an individual nature to which training should make a major contribution. Secondly, proficiency at these tasks is very highly related to the costs of maintenance, as I will document in a few minutes.

From these four areas we made up an 8-hour test of 30 individual performance exercises. Each was taken from a Technical Manual or from U.S. Army Armor School instructional material. Exercises were suggested by Armor School instructors and by Ordnance Corps Maintenance Technicians (OCMTs) employed at Fort Knox. The OCMTs reviewed all exercises and approved them prior to administration

of the test. After the Fort Knox men were tested, the Armor School reviewed the test and concurred in 29 of the exercises as given. An additional item of special equipment was added to the remaining exercise on their recommendation.

(SLIDE 2)

This slide shows the number of exercises of the different types. Note that there is a category of "spark plugs." These could have been distributed among the other categories, but seemed to make more sense when kept together. Incidentally, all spark plug exercises were given in one testing period.

I wish to emphasize that these exercises were actually performed on five common tactical vehicles--tanks, personnel carriers, and trucks. We did not question mechanics about their knowledge; rather they were given maintenance tasks to perform to the best of their ability. These photographs show testing in progress.

(PHOTOGRAPHS 1-4)

In this first photograph the problem was ignition timing and magneto synchronization. All tools and equipment necessary for this task were at hand. Sergeant Craig, the tester, has a sheet listing each step or operation in this task. After giving the subject his directions all the tester did was mark his scoring sheet as each step was completed. Note that there are two manuals on the table behind Sgt. Craig.

Valve adjustment is the task in the second photograph. The man bent over behind the power plant is the vehicle's driver. He assisted the subject by carrying out specific directions, but did

SLIDE 2

EXERCISES INCLUDED IN MECHANIC TEST:

Type	Number
TROUBLE SHOOTING	
Air-Fuel	3
Electrical	8
ADJUSTING	
With Special Equipment	4
Other	2
TESTING	
Electrical	4
Pressures	4
Specific Gravity	1
SPARK PLUGS	3
INSPECTING	1
TOTAL TEST	30

nothing unless the mechanic told him to. Vehicle drivers were used in this way at all test stations where it was appropriate.

In the 3rd photo the subject is attempting to identify a starter system malfunction on the M59 armored personnel carrier. Note the size and complexity of the testing device, the Low Voltage Circuit Tester.

In the fourth photograph M/Sgt. Ellis is observing a man trying to diagnose the ailment of this ¼-ton truck. The man is using a pressure gage. He never got close to the malfunction, which was a defective carburetor. Again, note the presence of driver. The testers, of course, were track vehicle mechanics trained to score their particular stations.

You no doubt noticed that man of several different grades are being tested. I will now describe the subjects.

We wanted to test working mechanics and motor sergeants. In addition to MOS, the support requirement specified that those taken for testing should actually be employed in organizational maintenance. In several of our sub-groups we actually tested every man on the post who fit the training-experience requirements. We tested men both at Fort Knox and in the 3rd Armored Division in Germany--about half the subjects came from each place, 482 mechanics and motor sergeants in all.

We wanted to learn how proficiency changed with experience, so we selected men of less than one year on the job, another group of one to five years on the job, and a third group of over five years maintenance experience. To get a sufficient number of motor sergeants we had to take them as they came, from one-half year to

2½ years of maintenance experience with the average at 11 (10.96) years. We also wanted to determine the relationship between training and proficiency. Somewhat over half of the TVMs were selected to have had a basic TVM course, somewhat less than half had not had this course. Again, the motor sergeants were taken as they came. 61% had taken a TVM course, 39% had not. We also wanted to determine the relationship between general intelligence and proficiency. We recorded the G.T. scores from the Form 20 as our estimate of general intelligence. The following slide gives the subjects tested.

(SLIDE 3)

Referring to the first category of the slide, the 50 Fort Knox subjects were in the last three days of the TVM course when tested. The 34 men of the 3rd Armored Division were "apprentice mechanics," who were learning on the job. They were of course performing maintenance in their units. There were no unusual characteristics about the other remaining groups.

Results

The next slide reports average performance by type of exercise. Results are reported separately for the 413 TVMs and the 69 motor sergeants.

(SLIDE 4)

You can see that performance is low in the areas of trouble shooting, adjusting tasks requiring special equipment, and electrical testing tasks.

I will now show you one of the consequences of errors of diagnosis in trouble shooting, a partial list of needless

SLIDE 3

MAINTENANCE PERSONNEL TESTED

Fort Knox	3rd Armored Division	Total
0-1 Year Experience		
50 TVM trained	33 TVM trained	83
	34 OJT	34
		117
1-5 Years Experience		
43 TVM trained	35 TVM trained	78
32 OJT	35 OJT	67
		145
Over 5 Years Experience		
41 TVM trained	35 TVM trained	76
36 OJT	39 OJT	75
		151
Avg. 11 Years Experience		
30 Motor Sergeants	39 Motor Sergeants	69
232	250	482

SLIDE 4

PERCENT OF SUCCESS BY TYPE OF EXERCISE

Type of Exercise	413 TVMs	69 Mtr. Sgts.
TROUBLE SHOOTING		
Air-Fuel	13.7%	20.3%
Electrical	13.2	12.5
ADJUSTING		
With Special Equipment	12.7	17.0
Other	54.6	68.1
TESTING		
Electrical	17.9	24.5
Pressures	43.5	54.7
Specific Gravity	44.3	49.3
SPARK PLUGS	61.1	67.1
Average Exclusive of Inspecting	26.4	31.4
INSPECTING (Scored Separately)	40.8	53.6

recommendations for replacement of parts.

(SLIDE 5)

We recorded almost 1150 such errors concerning 109 different assemblies or parts of the 5 vehicles in the test. Four hundred eighty-two men made 1150 errors, but the "lion's share" of these errors were made by the more experienced men including the motor sergeants. Among these more experienced men, those having had a TVM course were the more frequent offenders, not because the on-job trained are the better mechanics but because they more often refused to make a diagnosis. The figure you see there, $100,484.76, represents only the new price cost of the parts on this slide. It does not include labor or administrative costs. Apparently, these men believe in what is known as "DX" or direct exchange trouble shooting. It should be pointed out that whoever makes the diagnosis is usually the final authority. The TVM is seldom double-checked on his diagnosis.

Earlier I mentioned that we wanted to find out if the TVM course trained mechanics were superior to the on-job trained men. They are; the difference is statistically reliable for total test performance.

(SLIDE 6)

Having determined that TVM trained mechanics are superior, we checked on intelligence as shown by G.T. scores. Those selected for TVM training are, on the average, of superior mental ability. Mental ability is significantly related to proficiency test performance (as shown by the coefficient of correlation of .47). Because of this relationship we conclude that the better proficiency

SLIDE 5

PARTIAL LIST OF ERRORS OF DIAGNOSIS

Replacement Erroneously Recommended	Frequency
spark plug sets	210
generator	149
carburetor	115
regulator	10
magneto	191
starter (assembly or components)	90
distributor	10
engine	2

Needless Expenditure $100,484.76

SLIDE 6

SCHOOL vs. ON-JOB TRAINING

Number of Mechanics	Type of Training	Average success, 29 Exercises	Average on Inspection, 1 Exercise
237	School	30.0%	42.0%
176	On-Job	21.5	39.2

test scores of the TVM trained mechanics are due to their higher mental ability, as well as to their training.

One of the findings that surprised us very much is that there is very little gain in proficiency with increased years of experience on the job.

(SLIDE 7)

There are TVM course trained and on-job trained men in each group. The average amount of experience in each group was about 4 months for the first group, just under two years for the second, just under 10 years for the third, and just under 11 years for the motor sergeants.

When this study was planned there was no comprehension on our part of the proficiency levels we would find. Our purpose actually was to pin-point skill and knowledge deficiencies of the mechanics so that corrective action could be taken, and it was only after we had done this that we computed the average results and realized the gravity of the situation. One positive note we can sound is that we did succeed in isolating skill and knowledge deficiencies which promise excellent guidance for both on-job and TVM course training revision. These were common deficiencies or errors. Some were made by as many as 90% of the failing men on some exercises.

(SLIDE 8)

Here is what these personnel did <u>not</u> know.

Insufficient vehicle knowledge was shown in these ways: Inability or refusal to attempt an exercise on a particular vehicle, failure to note a missing fuel filter, recommendation of

SLIDE 7

EXPERIENCE AND PROFICIENCY

Number of Mechanics	Years Experience	Average Success, 29 Exercises	Average on Inspection, 1 Exercise
117	Less than 1 year	24.8%	30.2%
145	1-5 years	26.5	40.5
151	Over 5 years	27.5	46.8
Number of Maintenance Seargeants			
69	11 yrs. average	31.4	53.6

SLIDE 8

AREAS OF SKILL DEFICIENCIES

Knowledge of Vehicles

- Sub-systems
- Sub-system symptoms

Knowledge of Publications

- Utilization
- Location of Information
- Wiring Diagram Interpretation

Use of Special Equipment

Trouble Shooting

- Equipment
- Procedures

Double Checking

replacement of carburetors on a fuel injection engine, and straying off one electrical system on to another. Regarding sub-system symptoms, men were very commonly unable to tell an air-fuel from an ignition malfunction--which is why there were so many needless recommendations for spark plugs and magnetos.

On publications, an outstanding fault was failure to use them at all. The compression test, which most men did improperly, is accurately outlined in the TM. Men also generally ignored the TM table of contents and index, thus wasting considerable amounts of time.

Wiring circuit diagram interpretation, although a tremendous stumbling block now may be less of a problem in the future. The -20 series of the multiple manual concept, with their trouble shooting schematic drawings and directions, apparently will make wiring diagrams unnecessary. At least the new TMs, such as TM 9-2320-218-20 (M151 ¼-ton truck) have no wiring diagrams at all. Perhaps in another few years instruction on wiring diagrams will no longer be needed.

Regarding use of special equipment, a major problem is sheer failure to use it. Many men do not know how to use complex testing devices. One Senior mechanic of 17 years experience burned up some wiring on one of our ¼-ton test vehicles, "trouble shooting" it with a screwdriver. Failure to use TMs is related to failure to use special equipment, for the TM tells when it is necessary although it often does not show how to use it. (This applies to the older vehicles and TMs.)

We observed a great many errors in trouble shooting. Men

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did not know how to set up or adjust the Low Voltage Circuit Tester, didn't know how to get good contacts at check points, attempted to make a ground contact on a painted or greasy surface, and reversed their leads, to name the more common ones.

Men do not know their trouble shooting procedures. Notably, this includes failure to make operational checks, such as testing generator output with the engine revved up. Many of the generators needlessly condemned resulted from this, for nothing can be determined about the generator while the engine is idling. There also were other errors that may be summed up under the heading of lack of knowledge of systematic procedures.

Double checking of a diagnosis in trouble shooting was extremely rare. The mechanics could have checked their diagnosis of "bad mags" simply by revving up the engine and performing an rpm "drop check," if they had known—or thought—to do so.

This concludes the presentation of data. Col. Spires has some comments to make and then we will attempt to answer any questions you wish to ask.

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